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STORAGE-ROTS CAUSED BY DIPLODIA [1]

By GAUDENCIO M. REYES

One of the greatest difficulties which beset our farmers is the problem of combating the predatory insects and fungi which are found everywhere and cause great damage to our economic plants and to agricultural products in storage. Much of the loss can be avoided by a knowledge of the symptoms of the disease causing decay to stored crops. Storage-rot diseases, which are caused by a multitude of fungi, have not yet been carefully investigated in the Philippines. The writer has confined his work to storage-rots caused by *Diplodia*, a very common fungus trouble found on roots, tubers, fruits, and many other crops stored in the seed laboratory of the College of Agriculture. The crops within the scope of this investigation include various products affected by the organisms under, or allied with, the genus *Diplodia*. Several woody hosts and important food crops found infected with similar organisms have been included to find out whether the causal organisms are the same, and to determine whether these organisms will produce identical rot on stored products.

It was the purpose of this work to study the nature of the decay; the character of the causal organism; the behavior of the various species studied under the genera *Diplodia*, *Lasiodiplodia*, and *Botryodiplodia;* and to determine whether they were the same or if they could be transmitted from one host to another. Finally, practical suggestions for control or preventive measures from the results of the study were to be formulated. Coincident with this, a study was made of

[1] Thesis presented for graduation from the College of Agriculture, No. 111; Experiment Station contribution No. 32.

several small weevils which probably are of vital importance as agents in the transmission of the disease. The rôle played by these small insects deserves special attention, and presents a field for further study.

This work was carried on in the College of Agriculture during the College years, 1918-19 and 1919-20.

SURVEY OF LITERATURE

MOST IMPORTANT INVESTIGATIONS AND RESULTS

According to Taubenhaus (26), the first authentic report of a disease caused by *Diplodia* was in 1896. Harter, Weimer and Adams (9) believe that the disease has probably been present in the United States since the time the sweet potato began to be cultivated. Harter (8), in 1914-15, worked on storage-rots of economic aroids. According to his work *Diplodia tubericola* (E. & E.) Taub. was found to cause the most common and serious of the storage-rots. Cultural characters showed that the organism isolated from dasheen could not be distinguished from *Diplodia tubericola* (E. & E.) Taub. from sweet potato, and that the spores varied very little in size and shape. *Diplodia sp.* from mango and *Diplodia maclurae* Speg., also showed the same behavior in culture, but the spores of the latter were much smaller. These species of *Diplodia* were found to be wound parasites, and they produced disease more readily under dry conditions and at high temperatures. In another article, Harter, Weimer and Adams (9) made an investigation of seventeen fungi causing sweet potato storage-rots. In their field inoculations of sweet potatoes, no decay was produced. *D. tubericola* (E. & E.) Taub., was found to grow better under ordinary laboratory conditions than in a damp chamber.

Taubenhaus (25) successfully produced the typical "Java black-rot" on sweet potatoes by inserting bits of mycelium of several species of *Diplodia* and *Lasiodiplodia* into slits in the epidermis and cambium. The same kind of rot was produced by Taubenhaus (24) by spraying healthy roots with spores.

Reinking (17) found that inoculation of cassava, cacao, gabi, and sweet potato with a pure culture of *L. theobromae* (Pat.) Griff. et Maubl. obtained from cacao, resulted in a characteristic dry-rot. The pure culture isolated from decayed sweet potatoes also produced the same kind of rot on cacao, sweet potatoes, cassava, and papaya.

Meier (13) succeeded in producing the stem-end rot of watermelon by introducing *D. tubericola* (E. & E.) Taub., isolated from sweet potatoes, and a *Diplodia* from decaying watermelon found in Washington, D. C.

Copeland (7) mentioned that Hart was successful in producing the "brown rot" of cacao pod by inoculation with *Botryodiplodia* from coconut petioles. The spores formed in the inoculum differed from those of *D. cacaoicola* P. Henn. in that the former were slightly larger. Fredholm (7) pronounced the same fungus, *Diplodia*, on coconut petiole.

Howard (11) succeeded in growing *D. cacaoicola* P. Henn., isolated from the pod, on sterilized cacao and oak wood. The same organism isolated from the wood produced "die-back" disease on living trees and the "brown rot" on pods.

Pole Evans (16) investigated the cause of "black-rot" of citrus fruits in Natal, and found that all varieties were susceptible to the disease. The characteristic rot was produced in three days by inoculating Spanish lemons, peaches, and apples with pure cultures of *D. natalensis* Pole Evans.

Van Der Bijl (27) studied the "dry-rot" disease of maize caused by *Diplodia zeae* (Schw.) Lév., and the effect of feeding diseased ears to livestock. Harter (9), in 1915, inoculated six roots of sweet potato with *Diplodia zeae* (Schw.) Lév., but failed to produce infection on them.

The writer isolated a species of *Diplodia* from corn ears on September 12, 1919, and found that the general appearance of the diseased ears, the growth of the organism on corn meal and on potato agar, and the shape and size of spores were different from the description of Van Der Bijl.

Studies of the sweet potato diseases, including the Java black-rot, were made by plant pathologists of Maryland, New Jersey, Delaware, Virginia, and of the Bureau of Plant Industry, Washington, D. C. Their investigations dealt with the appearance and behavior of the different causal fungi and the methods of controling them (20.)

According to Petch (14) the "die-back" disease of *Hevea*, caused by *Botryodiplodia theobromae* Pat., was determined as *Diplodia rapax* Mas., which is capable of living both as a parasite and as a saprophyte. This is widely distributed in the tropics under a number of different names.

Van Hall (28) states that *Diplodia* is found in Grenada, St. Lucia, St. Vincent and Dominica. The same author states that a *Lasiodiplodia* occurs in Trinidad, and in Surinam, a *Chaetodiplodia* causing the "die-back disease" of the cacao. These "fructifications" were shown by Van Hall-de Jonge and Drost to be the fungus called *Diplodia cacaoicola* P. Henn.

Dr. P. A. Saccardo identified the material growing on the cacao from the Philippines as *Lasiodiplodia theobromae* (Pat.) Griff. et Maubl. The name of the fungus which produces dry rot on sweet potatoes, papaya fruit, pomelo, yams, and sugar cane is based on his determinations. [2] The cause of "Java black-rot" of sweet potato is known under three names; viz., *Lasiodiplodia tubericola* E.&E. (24), *Diplodia tubericola* (E. & E.) Taub. (8), and *Lasiodiplodia theobromae* (Pat.) Griff. et Maubl. (17).

Taubenhaus (25) concluded from the classification of the genus *Diplodia* by Fries in 1849, of *Botryodiplodia* by Saccardo in 1880, of *Diplodiella* and of *Chaetodiplodia* by Karsten in 1884, and of *Lasiodiplodia* by Ellis and Everhart in 1896, that there was no sharp distinction between them and that the first genus alone should be retained. He says:

> It is evident that the genus *Diplodia* under different hosts and climates may take on some or all of the characteristics of the recent genera *Chaetodiplodia*, *Lasiodiplodia*, *Botryodiplodia* and *Diplodiella*. *L. theobromae* (Pat.) Griff. et Maubl., has been placed by different workers in all the genera except *Diplodiella*.

According to Taubenhaus the genera *Rhynchodiplodia* and *Pellionellia* may be placed under *Diplodia* also, or may be eliminated entirely by further study. By reason of priority, only the genus *Diplodia* should be retained, as it includes all the characteristics upon which the others were founded.

GEOGRAPHICAL DISTRIBUTION

Diseases of plants caused by *Diplodia* have been reported from different parts of the world, and a number of these were found on agricultural products in storage.

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[2] Reinking, Otto A. Host index of diseases of economic plants in the Philippines. Philippine Agriculturist 8:38-54. 1919.

Cacao.—The "brown-rot" of cacao pods is known to occur everywhere. It was first reported by Howard, in 1901, in Grenada and subsequently in St. Lucia, Dominica, St. Vincent, and British Guiana (23). Cook (6) reported *L. theobromae* (Pat). Griff. et Maubl., in 1909, as the cause of the "scabby pod" of cacao in Grenada, Surinam and Dominica. According to Massee (12), the same disease in the West Indies and Africa was attributed to *D. cacaoicola* P. Henn. Baker (2) reports *L. theobromae* (Pat.) Griff. et Maubl., as the fourth invader on cacao pod after a series of attacks by other fungi in the Philippines. Reinking (17) mentions that the same fungus is present on cacao pods in the Philippines. *B. theobromae* Pat., was also found on cacao pods in Santo Domingo (4).

"Die-back" of cacao is prevalent in Grenada, St. Lucia, and Dominica (23). The fungus was first found by Hennings, in 1896, on wood of cacao (4). Massee (12) determined the causal organism as *D. cacaoicola* P. Henn. A species of *Chaetodiplodia* is said to occur on t wigs of cacao in Surinam (6).

Citrus.—The "black-rot" of citrus caused by *D. nataiensis* Pole-Evans was first reported, in 1909, from South Africa. Five other species of *Diplodia* have been observed from time to time as causing damage to citrus fruits and other parts of the tree. *D. aurantii* Catt., was found in Italy on leaves and branches; *D. citricola* McAlpine was reported from Australia on lemon twigs, stems, green fruits, and leaves; and on the twigs and fruit of citron. *D. destruens* McAlpine occurs on orange and lemon leaves in Australia. *D. hesperidica* Speg. was observed on fallen leaves and branches of *C. aurantium* in Argentine; and *D. heteroclita* Dur. & Mont. attacks the leaves of *C. aurantium* in Algeria.

Coconut.—A species of *Botryodiplodia* living as a parasite on the petioles of coconut in Trinidad was identified by Patouillard, and one on the roots of coconuts in Travancore by Butler. The latter, however, was not certain of his determination. *Diplodia* was also found associated with the bud rot of coconuts in Cuba (7).

Maize.—"Dry-rot" disease on maize, caused by *D. zeae* (Schw.) Lév., was first reported by a farmer in Licking Co., Ohio, in 1906, and was then studied the same year at the Agricultural Experiment Station of that state (19). It occurs also in Europe, South Africa, in the provinces of Natal, Transvaal, and Swaziland (27).

Hevea.—The "die-back" disease of *Hevea* caused by *Botryodiplodia theobromae* Pat., is prevalent in the Malay Peninsula (18). *Diplodia* was found on *Hevea* in Ceylon, Federated Malay States and Surinam (28). *L. theobromae* (Pat.) Griff. et Maubl., was reported as a wound parasite on *Hevea* (21).

Mango.—Charles (5) found a form of *Lasiodiplodia* on mangoes brought from Florida.

Pineapple.—A species of *Diplodia* was reported in the West Indies (6).

Sugar cane.—*D. cacaoicola* P. Henn. was found living both as a parasite and a saprophyte on sugar cane (6).

Sweet potato.—*L. tubericola* E. & E. was first reported on sweet potatoes brought from Java to the Louisiana Experiment Station in 1894 (21). It was also found in Florida (22) and in Delaware (24). In the spring of 1895, the same fungus first called *D. tubericola* (E. & E.) Taub., was observed on sweet potatoes sent to Baton Rouge (26). The disease it produces is especially widely distributed in the tropics. It is known to occur in Cuba, Isle of Pines, United States, Japan, Porto Rico, South America, and the Philippines.

Tea.—*B. theobromae* Pat., (1892) was found to be the cause of the root disease of tea (6).

ECONOMIC IMPORTANCE

Losses.—Diseases caused by *Diplodia* are present almost the world over and cause a considerable amount of the destruction of agricultural crops.

Reports of losses due to the fungi on sweet potatoes in storage houses in the United States alone, amount to several million dollars annually (9). Although all the loss cannot be attributed to *Diplodia* alone, Harter (8) considers it to be the most destructive of all the storage-rots. Bailey (3) says that this is the most serious disease on the sweet potato because it destroys the entire tuber. The disease is not readily noticeable, and affected tubers are likely to be stored with sound ones.

A species of *Diplodia* was discovered as the cause of some loss of watermelons in Washington, D. C. (13).

D. zeae (Schw.) Lév., or "dry-rot" of corn, is considered destructive to corn crops in Europe, America, and South Africa (27).

The "black-rot" of citrus fruits caused by *Diplodia natalensis* Pole-Evans was found to affect all varieties of citrus in South Africa, but the amount of loss was not recorded (16).

In the Philippines over fifty per cent of the cacao pods are lost through fungus troubles (1), but the loss due to *L. theobromae* (Pat.) Griff. et Maubl. alone is not known. Serious damage was reported from all cacao growing regions of the world.

Pods of *Phaseolus lunatus* Linn. (patani) in the Philippines are attacked by *D. phaseolina* Sacc., even before maturity (1). The amount of damage, however, is not known.

The writer made an observation of the susceptibility of sweet potatoes stored in the storeroom of the College of Agriculture to *L. theobromae* (Pat.) Griff. et Maubl. Nine varieties of twelve roots in each lot were kept separately in the laboratory where specimens infected with *L. theobromae* (Pat.) Griff. et Maubl. were present. These roots were newly harvested and they were stored under laboratory conditions on December 2, 1918.

On January 1, several were found infected; and on February 24, about two months later, nearly all the roots were infected except the variety Amoroso. The average amount of loss was about fifty per cent. It was found that if the diseased roots were picked out and the sound ones disinfected, little loss occurred.

A disease caused by *Diplodia* was observed on corn ears harvested at this College during the months of August and September, 1919. As much as 15 per cent loss was estimated of the corn crops stored in the agronomy laboratory; of the ten varieties stored all were found susceptible.

A large amount of loss was observed in the seed laboratory of the College of Agriculture on stored tubers of gabi, yautia, and yams; on roots of cassava and sweet potatoes; and on corn. The other stored crops found infected were fruits of mango, jackfruit, papaya, citron, and banana. The diseased fruits of egg-plant, guanabano, squash, patani, cacao, cotton bolls, and the wood specimens used in this investigation were collected from the College Farm.

Probable sources of infection.—Aside from the numerous agents responsible for the dissemination of the disease, the danger of infection is enhanced by the prevalence of several species of *Diplodia* which are now known to attack a wide range of plants. Harter (9) believes from his findings that species of *Diplodia* from other hosts, injected into sweet potatoes, dasheens, or watermelons, cause identical rots. In another article Harter (8) states that there are many species of *Diplodia* which may prove to be the same. At this College alone a number of hosts attacked by species of *Diplodia*, *Lasiodiplodia* and *Botryodiplodia* were found. The following table shows a list of host plants, besides cacao, attacked by *Diplodia* and its allies.

TABLE I.—*Plants attacked by Diplodia and its allies.*

No.	Fungus.a	Host.		Diseased part.
		Scientific name.	Common name	
1	*L. theobromae* (Pat.) Griff. et Maubl.	*Citrus maxima* (Burm.) Merr.	Pomelo	Fruit
2	*L. theobromae* (Pat.) Griff. et Maubl.	*Dioscorea esculenta* (Lour) Burkill	Yams	Storage rot
3	*L. theobromae* (Pat.) Griff. et Maubl.	*Saccharum officinarum* Linn.	Sugar cane	Dead stalk.
4	*Botryodiplodia curta* Sacc.	*Phaseolus vulgaris* Linn.	Patani	Dead pods
5	*Diplodia agaves* Niessl	*Agave cantala* Roxb	Maguey	Dead leaves
6	*Diplodia ananassae* Sacc.	*Ananas comosus* (L.) Merr.	Pineapple	Dead leaves
7	*Diplodia arecina* Sacc.	*Areca catechu* Linn.	Betel Palm	Dead leaves
8	*Diplodia artocarpi* Sacc	*Artocarpus communis* Forst	Breadfruit	Dead branches and leaves
9	*Diplodia artocarpina* Sacc	*Artocarpus integra* (Raderm.) Merr.	Jackfruit	Dead leaves
10	*Diplodia aurantii* Catt	*Citrus nobilis* Lour.	Naranhita or Mandarin	Dead leaves
11	*Diplodia cococarpa* var. *malaccensis* Tassi	*Cocos nucifera* Linn.	Coconut	On husks.
12	*Diplodia epicocos* Cke	*Cocos nucifera* Linn.	Coconut	Dead petioles
13	*Diplodia epicocos* var. *minuscula* Sacc.	*Cocos nucifera* Linn.	Coconut	On husks
14	*Diplodia lablab* Sacc.	*Dolichos lablab* Linn.	Lablab bean	Dead stems
15	*Diplodia durionis* Sacc	*Durio zibethinus* Murr.	Durian	Fruit rot.
16	*Diplodia mori* West.	*Morus alba* Linn.	Mulberry	Dead branches
17	*Diplodia crebra* Sacc.	*Musa sapientum* Linn.	Banana	Dead fruits
18	*Diplodia phaseolina* Sacc.	*Phaseolus vulgaris* Linn.	Patani	Dead pods.
19	*Diplodia ricinicola* Sacc.	*Ricinus communis* Linn.	Castor-oil plant	Dead stems.
20	*Diplodia degenerans* Died.	*Solanum melongena* Linn.	Eggplant	Dead fruits
21	*Diplodia tamarindica* Sacc.	*Tamarindus indica* Linn.	Tamarind	Dead parts
22	*Diplodia*	*Macaranga bicolor*	Hamindang	Dead branches
23	*Diplodia*	*Dysoxylum* sp		Dead branches
24	*Diplodia*	*Aphanamixis* sp		Dead branches
25	*Diplodia*	*Canarium villosum* Miq.) F-Vill.		Dead branches
26	*Diplodia*	*Leucaena glauca* Benth.	Ipil-ipil	Dead branches
27	*Diplodia*	*Gliricidia sepium* (Jacq.) Steud	Cacawate	Dead Branches
28	*Diplodia*	*Carica papaya* Linn.	Papaya	Dead trunk
29	*Diplodia*	*Ricinus communis* Linn.	Castor-oil plant	Dead trunk
30	*Diplodia*	*Passiflora quadrangularis* Linn.		Living fruit

a1-21. Reinking, Otto A., Philippine economic-plant diseases. Philippine Journ. Sci., Sec. A, **13**: 165-274 *Pl. 1-22, fig. 1-43*, 1918.

Idem, Host index of diseases of economic plants in the Philippines. Philippine Agriculturist **8**:38-54. 1919. Nos. 22-30, not yet identified.

From Table I it is seen that the species of *Diplodia* and its allies live on many different kinds of plants. It may be assumed that these organisms would cause storage-rots if used for inoculation.

GENERAL SYMPTOMS

STORAGE-ROTS AND WOODY HOSTS

At an early stage, storage-rots of roots, tubers, and fruits caused by *Diplodia* can hardly be distinguished, and may be mistaken for other storage troubles. As the disease advances the general characteristic is the blackening of the host and the production of small pustules, hard, warty outgrowths, or a black powdery mass of spores. The infected tissue is at first soft. The fungus gradually spreads in all directions and covers the entire root, tuber, or fruit. A rapid loss of moisture takes place, and eventually the host is rendered dry, shrivelled, and hard. Internally, the infected tissue becomes browned or blackened. The small pustules or warty outgrowths are the pycnidia. Fruits decay much quicker than roots or tubers. First, wounded storage organs become infected, then the sound ones by direct contact with the diseased ones.

The prevalence of tiny pustules which come out through ruptures on the bark are the external symptoms of the disease on woody hosts. Frequently, the small warty projections are also accompanied by a thick felty mass of grayish black mycelia. The diseased tissue, when cut longitudinally, is grayish black in color. The attacked wood is very light in weight, hard, and dry. The bark is wrinkled.

ISOLATION OF CAUSAL ORGANISMS

After microscopic examination of the causal organism, cultures were made and kept on potato agar. A list of these cultures is given in Table II.

TABLE II.—*List of cultures.*

Culture No.	Causal organism.	Host.	Condition of diseased portion.	Date isolated.
1	*Lasiodiplodia theobromae* (Pat.) Griff. et Maubl	*Ipomoea batatas* (L.) Poir	Decayed root	July 23, 1918.
2	*Diplodia*	*Mangifera indica* Linn	Decaying fruit	Aug. 1, 1918.
3	*Diplodia*	*Musa sapientum* Linn	Decaying fruit	Aug. 1, 1918.
4	*Lasiodiplodia theobromae* (Pat.) Griff. et Maubl	*Theobroma cacao* Linn	Mummified fruit	Aug. 9, 1918.
5	*Diplodia*	*Cocos nucifera* Linn	Heart of coconut	Aug. 30, 1918.
6	*Diplodia*	*Gossypium hirsutum* Linn.	Decaying boll	Aug. 31, 1918.
7	*Diplodia*	*Artocarpus integra* (Raderm.) Merr	Decayed fruit	Aug. 31, 1918.
8	*Lasiodiplodia theobromae* (Pat.) Griff. et Maubl	*Carica papaya* Linn	Decayed fruit	Sept. 19, 1918.
9	*Botryodiplodia anceps* Sacc. et Syd.	*Morus alba* Linn	Dead twigs	Sept. 23, 1918.
10	*Lasiodiplodia theobromae* (Pat.) Griff. et Maubl	*Saccharum officinarum* Linn.	Dead stems	Sept. 25, 1918.
11*a*	*Diplodia*	*Citrus nobilis* Lour	Living citrus tree	Dec. 16, 1918.
12	*Diplodia*	*Oreodoxa regia* HBK	Dead trunk	Feb. 14, 1919.
13	*Diplodia*	*Colocasia antiquorum* Schott	Stored tuber	Feb. 14, 1919.
14	*Diplodia*	*Xanthosoma sagittifolium* Schott	Stored tuber	Feb. 14, 1919.
15	*Diplodia phaseolina* Sacc	*Phaseolus lunatus* Linn	Stored pod	Feb. 26, 1919.
16	*Diplodia*	*Manihot utilissima* Pohl	Stored root	Feb. 26, 1919.
17	*Diplodia*	*Aphanamixis sp*	Dead branches	Mar. 11, 1919.
18	*Diplodia*	*Ficus pseudopalma* Blanco	Dead branches	Mar. 11, 1919.
19	*Diplodia manihoti* Sacc	*Manihot utilissima* Pohl	Dead stems	Mar. 11, 1919.
20	*Diplodia caricae* Sacc	*Carica papaya* Linn	Dead petioles	Mar. 11, 1919.
21	*Diplodia cococarpa* Sacc	*Cocos nucifera* Linn	Dead husk	Mar. 11, 1919.
22	*Diplodia*	*Aleurites moluccana* (L.) Willd	Dead branches	Mar. 18, 1919.
23	*Diplodia*	*Cucurbita maxima* Duch	Dead fruit	Apr. 11, 1919.
24	*Diplodia*	*Citrus medica* Linn	Stored fruit	Apr. 11, 1919.
25	*Diplodia*	*Annona muricata* Linn	Decaying fruit	July 14, 1919.
26	*Diplodia*	*Solanum melongena* Linn	Decaying fruit	Aug. 11, 1919.
27	*Diplodia*	*Zea mays* Linn	Stored ear	Sept. 12, 1919.

*a*Furnished by Prof. O. A. Reinking. Isolated from Citrus bark-rot.

METHOD OF ISOLATION EMPLOYED

The most feasible method of isolation, the single-spore method, was used in all cases except for culture 11, which was furnished by Prof. Reinking. The isolation was made in a room free from draft, in a well sterilized isolation box. The organism was examined under the microscope to be sure that it was the right fungus. With the point of a flamed scalpel, a quantity of the black mass of spores was obtained and diluted in a drop of water on a glass slide. A few of the spores were transferred with a platinum loop into a petri dish, precaution being taken to exclude other organisms, and all instruments and the water were sterilized. A liquified potato agar, cooled to 42°C., was then poured into the dish. The spores were mixed thoroughly with the medium and allowed to solidify.

The plate was inverted and examined under the low power of the microscope to locate an isolated spore. The location was marked by an ink dot on the petri dish. A ring or a small rectangle was cut around the spore with a flat-ended, sterilized platinum needle, and the agar bearing the spore was transferred to a fresh sterile plate of potato agar. Two to four of these rings or rectangles were transferred to each of several petri dishes, so that the spore that was free from any other organism might be selected. The plate was examined at sufficient time intervals to establish beyond doubt that no contamination had developed. The spores germinated in from two to six hours under ordinary laboratory conditions. The plate was inverted and examined under the low power of the microscope to see if the spores germinated. This avoided the transfer of contaminated cultures. A bit of the germ tube was then transferred into an agar slant.[3]

Cultures of the various fungi isolated were kept on potato cylinders for the work on spore measurements, for drawings, and for the study of cultural characters. For inoculation experiments and study of the growth, cultures were maintained on potato agar.

INFECTION EXPERIMENTS

To test if the fungus isolated from different hosts caused the same trouble when transferred from one host to another, two series of cross-inoculations were made, using for the first set cultures 1 to 10, inclusive; and for the second, cultures 1, 4, 9, 11, 15, 19, 20, and 24. The fungi used in these sets of cross-inoculations were not all identified as to various possible species. The ones already known included species of the three genera, *Diplodia*, *Lasiodiplodia*, and *Botryodiplodia*. In the first series, the inoculations were not made on all hosts, and only the principal hosts were used. An inoculation of roots of cassava was also carried out with cultures 1 to 15. In these experiments all precautions were taken to prevent contamination.

INOCULATION OF CARICA PAPAYA LINN.

On October 5, 1918, ten sound and nearly ripe fruits of papaya were inoculated with the first ten cultures listed in Table II. They were disinfected with mercuric chloride (1 to 1000) and after ten minutes were rinsed with two changes of sterilized water. A small wound was made on each fruit with a sterilized scal-

3 Methods in Plant Pathology, College of Agriculture.

pel, and bits of mycelium of the organisms used were inserted into the wound by means of a sterilized platinum needle. Control fruits were maintained in which all other treatments were made except the addition of mycelium. The fruits, including the control, were kept inside the laboratory in an open, clean seed-box covered with Manila paper.

Of the ten fruits inoculated, except the control, which was found to be infected with another fungus, all were severely infected. This was shown by the blackening of the infected portion and the spread of a grayish white fungus growth. On October 14, the fruits were completely rotted. A black mold and *Fusarium* were also present; but through the rapid loss of moisture the condition of the fruits favored the growth of the organisms introduced. In some cases the contaminations seemed to have disappeared. Due to the loss of water content and infection, the fruits shrank and became very light in weight and brittle. The presence of black warty outgrowths on the epidermis was very distinct. All the causal organisms were recovered in pure cultures when reisolated. The check that was kept under a bell-jar was infected with *Fusarium.*

INOCULATION OF SACCHARUM OFFICINARUM LINN. VAR. LOUISIANA STRIPED

On October 5, 1918, ten cuttings of sugar cane of about two internodes in length were inoculated with cultures 1 to 10 (Table II), inclusive, by making longitudinal slits in the rind and inserting bits of mycelium. The inoculated cuttings and the control were placed under bell-jars to keep them in a moist atmosphere. In two to three days the wounded portions showed signs of infection. In all cases the buds and roots grew, so the sugar cane became somewhat resistant. The organisms, however, caused complete decay. The young shoots and roots died and tiny black pustules were produced through ruptures on the rind and occasionally at the cut ends. The cut surfaces including the check were contaminated with a black mold. On October 29, *Diplodia* spores were found by microscopic examination of the pustules. Positive reisolations were obtained. The cuttings eventually became black, dry, shrivelled and very light in weight. The control which was wounded remained sound.

INOCULATION OF MUSA SAPIENTUM LINN. VARS. SABA AND HAWAIIAN DWARF

The two varieties of fruits used in these experiments were green, but mature. Ten fruits of both varieties were inoculated on October 5, 1918, with the same set of cultures and in the same way as in the papaya inoculation. These were also confined under moist bell-jars. Both varieties were quickly infected in a day. A blackening of the fruits was observed on October 9, and complete rotting took place in about two weeks. One fruit of the Hawaiian Dwarf variety and two of the Sabá were infected with a mold. The organisms were recovered successfully in reisolations. The check remained sound for a long time. The final decay of the check was due to over-ripeness. The characteristic rot found on sweet potatoes was produced on the inoculated bananas, especially in those fruits inoculated with cultures 8, 9, and 10. The fruits became dry, hard and mummified.

INOCULATION OF IPOMOEA BATATAS (L.) POIR.
VAR. MANILA PULA

On October 5, 1918, ten fresh roots of sweet potato were inoculated in the manner described for the papaya and with the same cultures. The roots were placed on moist cotton under bell-jars. The control was similarly treated, but without the addition of the fungus to the slits. All the roots grew and the fungus developed only in three of the inoculated roots. The disease developed very slowly. Only two were completely rotted, and the third was only slightly infected. The causal organisms were recovered in pure cultures when reisolated. The check remained sound.

Eight newly harvested sweet potatoes were inoculated on August 24, 1918. Two roots were inoculated with each of the pure cultures 1 to 4, inclusive. These and the control were subjected to the same conditions as in the preceding experiment. All of the roots remained sound. The roots sprouted through the absorption of moisture; this probably made them somewhat resistant.

INOCULATION OF THEOBROMA CACAO LINN.
TYPE FORASTERO VAR. ANGULATA

Both ripe and unripe pods were used in this inoculation. Ten pods were inoculated on February 17, 1919, with the ten cultures, and all the necessary precautions were taken. The inoculated pods and the control were placed in the damp chamber.

The mature pods were found to become infected sooner than the unripe ones. It was found that rotting started in from three to five days. The first symptom was a browning of the portion inoculated, forming a more or less circular patch. The fungus then spread in all directions, and the pods were completely rotted in about nine days. Pycnidia were produced before the pods were totally decayed. The results of reisolation were positive. The control was infected with another fungus, but it did not show any symptom of the presence of *Diplodia*.

On July 29, 1919, cultures 13, 14, 16, 25, and 27 were also introduced by making slits in the rind of cacao, and inserting bits of hypae.

One pod was inoculated with each culture. One was wounded without the addition of the fungus for the check. These were also confined in the moist chamber. The organisms used were all recovered in reisolation. In this experiment the check remained healthy, but the same rot was produced in the inoculated pods as was described in the former inoculation of cacao fruits. When the last record was taken the inoculated pods were black, hard, shrivelled, brittle and light in weight.

INOCULATION OF MANIHOT UTILISSIMA POHL.

On February 25, 1919, another series of inoculations was carried out with the first 14 cultures. Newly harvested roots of cassava were injured through the hard coat beneath the epidermis. One root was used for each culture, and bits of mycelium were inserted in the wound. All, including the check, were put under moist bell-jars.

The roots showed evidence of decay in from three to four days. The organisms worked internally and came out through wounds, or by rupturing the epidermis either transversely or longitudinally. The infected roots were softened and

spores appeared before they were completely decayed. All were completely rotted by March 18. The roots finally became hard, dry, shrivelled, and the weights were much reduced. The powdery mass of coal-black spores covered the entire root in the advanced stage of decay. Positive reisolations were made from each. The control was infected with *Rhizopus nigricans* Ehrb.

INOCULATION OF THEOBROMA CACAO LINN.

On July 28, 1919, seven mature pods of cacao were inoculated with the following cultures: 1, 4, 9, 11, 15, 19 and 20; and one pod on December 23, 1919, with culture 24. All necessary precautions observed in previous inoculation experiments were taken. The pods were stabbed in the grooves with a flamed and cooled scalpel, and bits of mycelium were inserted by means of a sterilized platinum needle. The check was also wounded, but no hyphae were inserted. All of the pods were placed under bell-jars with moist cotton at the bottom on petri dishes.

A browning, starting from the point of inoculation, was observed in from three to four days. It took eleven days to completely rot the pods, but some were severely infected in a much shorter time. The pods became soft, and in the early stage of infection, the fruit was entirely covered with a felty, whitish gray fungus growth which gradually turned black. Pycnidiaa ppeared as numerous pimple-like protuberances on the rind, or in colonies like those produced on inoculated papaya, banana, cassava and sweet potato. On opening the pods the beans were found to be covered with grayish black mycelia, the cotyledons were browned, and the pedicels of the fruit were covered with pycnidia. The moisture of the pods evaporated, and they became very black, brittle, hard, shrivelled, and light in weight. The pods inoculated with cultures 11 and 19 were contaminated with a black mold. The control was infected with another fungus. The reisolations from the inoculated fruits were successful.

INOCULATION OF PETIOLES OF CARICA PAPAYA LINN.

Young, sound petioles of papaya, about twelve centimeters in length, were disinfected and inoculated on July 28, 1919, with cultures 1, 4, 9, 11, 15, 19 and 20, and one on December 23, 1919. A slit was made in the epidermis and bits of hyphae with a little nutrient media were inserted. All were kept in moist chambers.

The petioles were infected in from three to four days, and in about a week all were completely decayed. Culture number 11 produced slight infection. They were rendered soft and moist. At the stage when a thick growth of greyish mycelium covered the petioles, which gradually turned black, pycnidia were noticed. In the later stage of infection, the petioles became dry and very much reduced in weight through rapid loss of moisture. Black, hard, and irregular outgrowths, covered with a thick mass of black mycelium, or with masses of sooty black spores, were produced on the epidermis. All petioles, except those inoculated with cultures 4 and 24, together with the control, were contaminated with a species of ascomycete which is prevalent on papaya petioles. The causal organisms were recovered in pure cultures, except from the petiole inoculated with culture 15, which produced an entirely different fungus.

INOCULATION OF MANIHOT UTILISSIMA POHL.

On July 28, 1919, young and old cuttings of fresh cassava branches, about eleven centimeters in length, were inoculated in the same manner as the papaya petioles and placed under bell-jars.

Infections, shown by the blackening of the bark from the point of inoculation, started in from three to five days. This was more noticeable on the younger branches than the older ones. The mycelium worked beneath the bark and came out through the leaf scars, and at both ends of the cuttings. In some cases the buds germinated, but were killed by the organisms used in the inoculation. The diseased lesions were soft. In about a week all the cuttings were completely decayed. A felty, black fungus growth appeared on some parts of the cuttings and minute black pustules on the other portions of the cuttings, which were dry at the time. On September 12, 1919, the cuttings were split and the pith and the wood were found to be grayish black in color, which showed the presence of mycelium. The reisolations were all positve and the check remained healthy.

INOCULATION OF MORUS ALBA LINN.

Fresh cuttings of mulberry branches were also inoculated, and the treatment given was the same as in the inoculation of the cassava cuttings.

Infection was observed in from four to eight days. The younger portions of the branches were infected earlier. The mycelium worked beneath the bark and came out of the leaf scars and at the cut ends. The bark was ruptured by the production of pycnidia which, at first, appeared as grayish pustules and later turned black as the spores emerged. In the advanced stage of infection the branches became dry, hard, and the bark wrinkled. The woody portion and the pith was also found to be infected. It is seen therefore that most of the infections were confined to the wound. The cuttings inoculated with cultures 9 and 24 were severely infected, but all of the others grew. The organisms were successfully reisolated and the check remained healthy.

INOCULATION OF CITRUS

Living trees.—Healthy branches of living trees of *Citrus nobilis* Lour. (mandarin) in the field were selected and inoculated with the same set of cultures used in the inoculation of mulberry cuttings. The portion of the branches were washed thoroughly with mercuric chloride (1: 1000) for ten minutes and then washed with sterilized water. A slit was then made in the bark with a sterilized scalpel, and bits of mycelium with a little nutrient media were inserted with a sterilized platinum needle. Cotton, moistened with boiled water, was placed around the branches below the wound, which was then carefully covered with paraffined paper.

Of the cultures, numbers 9, 11, 19, 20, 24 and 27 were used on September 21, 1919; and numbers 1, 4 and 15 on December 24, 1919. In from two to five days infection was noticed by a discoloration of the inoculated portion, and by the exudation of a clear, brownish, gummy liquid. The first and most severely infected branch was the one inoculated with culture 11. Spores were produced on the diseased branches inoculated with cultures 1, 15, 20 and 27, but none on the branch infected with culture 11. The younger branches inoculated were more susceptible, and in some instances, were killed in the same manner as those

inoculated with cultures 4 and 15. The causal organisms were recovered in pure cultures. Cultures 9 and 19 did not produce any sign of infection. On the older branches the infection was mostly confined to the wound. The check remained healthy and the wound healed.

Seedlings.—Four species of citrus seedlings, eight to twelve months old, were inoculated at different times with the pure culture of a *Diplodia* (culture 11) isolated by Prof. Reinking from bark rot of *Citrus nobilis* Lour. The precautions and treatment of the preceding experiments were given to these. A yellowing of the portion inoculated was the first indication of the disease. In older infections a sticky, brown exudate and a greyish fungus growth were produced. Some of the stems were girdled; the seedlings were defoliated and finally succumbed to the disease. In others the infection was confined to the wound, while still others were not infected at all.

Two of the four seedlings of *Citrus maxima* (Burm.) Merr. inoculated were killed, one slightly infected, and one not infected. It took five days for the fungus to produce infection. The causal fungus was successfully reisolated. Two checks were kept and both remained healthy. The wound of the control healed.

In the five seedlings of the Zabon variety inoculated on March 14, 1919, the infection started in five days. Two were killed, two slightly infected, and one not infected. Reisolations made from diseased seedlings were positive. The check remained healthy.

One seedling of *Citrus medica* Linn., (citron) was inoculated on the same date as the Zabon. The sign of infection was visible in five days. The seedling was killed. Zabon was used as check.

On August 19, 1919, three seedlings of *Citrus nobilis* Lour. were inoculated with the same organism. It took the fungus three days to produce infection on these seedlings. They became infected but the disease was confined to the wound. An irregular greyish brown spot was produced, showing the presence of minute black specks. Reisolations were positive. The wound of the control healed.

Seven-months-old seedlings of *Citrus maxima* (Burm.) Merr. were inoculated by the stab method on August 15, 1919, with cultures 1, 4, 9, 11, 15, 19 and 20 and then kept in a moist chamber with moist sterilized sphagnum moss.

It is very interesting to note in this connection that only the seedling inoculated with culture 11 manifested a slight infection. This was shown by the yellowing of the infected portion and the exudation of a viscous, brown liquid, and the dropping off of the leaves. *C. maxima* (Burm.) Merr. showed a certain degree of resistance to *Diplodia*. The causal organism was reisolated successfully. Neither of the non-infected seedlings nor the control was defoliated, and the wounds healed.

INOCULATION OF CITRUS MEDICA LINN.

On September 19, 1919, eight fruits of citron were inoculated with cultures 1, 4, 9, 11, 15, 19, 20 and 24.

The fruits were infected in from two to six days. The first indication of the disease was the appearance of brown circular spots covered with greyish mycelium. The infected area was soft and sunken, and a characteristic sour smell was evident. The fruits were completely decayed in about two weeks and were covered by the greyish mycelium. A clear, brown liquid exuded in drops hanging

around the fruit was noted in those inoculated with cultures 1, 4 and 15. After the moisture content escaped rapidly, the fruits blackened with the formation of warty outgrowths or of minute black pustules on the skin. *Penicillium*, a black mold, and *Schizophyllum commune* Fr. were found on some of the fruits when they were completely rotted. The contaminated fruits were then taken out of the moist chambers. When they dried out the spores of the fungi used escaped. These fruits were placed in a corner of the room where the afternoon sun could reach them. Successful reisolations were made from each. The check remained very healthy.

INOCULATION OF PHASEOLUS LUNATUS LINN.

Eight fresh pods of patani were inoculated on October 21, 1919. The same cultures and method of inoculation as in cacao was used. All the necessary precautions to prevent contamination were taken. The pods were inclosed in damp chambers.

It was found that patani pods were very susceptible, as pods inoculated with cultures 4, 9 and 15 were infected in about two days and the remainder were completely infected in from 5 to 9 days. A blackening of the portion infected was evident, and thick growth of grayish mycelium spread over the surface, covering the entire pods. In a few days numerous pycnidia, from which abundant spores escaped, were formed on the surface. In old stages, the pods became very hard, dry and twisted. The reisolations made from each were positive and the check remained sound.

INOCULATION OF IPOMOEA BATATAS (L.) POIR.

On October 28, 1919, eight fresh roots of sweet potatoes were inoculated with the same set of cultures by the same method used in the inoculation of cacao, observing the same precautions.

Six weeks elapsed before any sign of infection was observed. The moist cotton was removed from the bell-jars on November 23. Of the eight roots inoculated, only the two inoculated with cultures 1 and 4 were found decayed on December 16. The roots grew because the moist condition to which they had been subjected had made them somewhat resistant. The reisolations made from the two infected roots were positive. The control remained sound.

On November 22, 1919, eight other roots were inoculated with the same cultures by smearing spores on a small cut made at one end. These roots were disinfected and confined in bell-jars without a supply of extra moisture.

In from five to ten days the roots were infected. The first symptom of the disease was a slight browning of the inoculated portion. Then the organisms spread and gradually caused a complete browning of the roots from one end to the other. At this stage of the disease, the roots were rendered soft, and smelled sweet. Before the roots had completely rotted, the formation of pycnidia could be seen through the epidermis on the parts first infected. These numerous pycnidia then worked through the epidermis and appeared as black, dome-like projections on the surface. The spores escaped and imparted a sooty black appearance to the roots. Some of the roots were entirely rotted in about four weeks, while others were rotted much later. Finally the roots shrivelled and became hard. The organisms were recovered in pure cultures. On examination on February 16, 1920,

the sweet potatoes inoculated with cultures, 1, 4, 11, 15, 19 and 24 were completely decayed. The root inoculated with culture 9 was two-thirds rotted, and the one infected with culture 20 was one-third rotted. The check was perfectly sound.

DESCRIPTION OF THE CAUSAL ORGANISMS

MORPHOLOGY

To get a general idea of the character of the various fungi isolated in pure culture, drawings of mycelium and spores from most cultures were made under the high power of the microscope with a camera lucida, from fresh mounted specimens; but the drawings are not included in the present paper. The specimens used were from cultures on cooked potato cylinders. The morphological study upon the structure of the vegetative and reproductive parts were made from pure cultures in potato cylinders. The descriptions of the pycnidia, conidiophores, and paraphyses were made from the mounted specimens also obtained from pure culture on the same medium.

Mycelium.—In general the mycelium of all cultures grows very abundantly in masses. Under the high power of a microscope, it is hyaline when young, and dark brown when old. In both stages, however, the mycelia are septate, very much branched, and granular. In the older stage, the mycelium is thick-walled and less granular; occasionally the cell bulges at one end.

Pycnidia.—The pycnidia are generally produced in groups and form small warty projections on the surface of the medium. These projections are hard, coal black, and consist of a number of pycnidia. The pycnidia are of various sizes and shapes and inclose the conidia, conidiophores and paraphyses, which are protected by a hard, thick and compact mass of mycelium.

Conidiophores.—The conidiphores are difficult to distinguish, as the conidia are seldom found attac hed to them. The spores separate before they are mature. The conidia are borne signly and apically on short hyaline conidiophores. The conidiophores arise from the walls of the pycnidia among the paraphyses.

Paraphyses.—The paraphyses are narrow, slender stalks produced in large numbers in the pycnidia. They are hyaline, like the conidiophores, and are vacuolate or ganular.

Conidia.—The spores are hyaline, non-septate and very granular when young, but two-celled and dark brown when mature. Occasionally, single-septate hyaline spores are found. The mature spores are usually striped longitudinally with a very distinct band around the median line. The spores vary in size and shape and are either oval or elliptical. Conidia are formed readily on potato cylinders, but very sparingly on potato agar. On potato cylinders the spores are produced in about two weeks. They germinate quicker in distilled water than on agar plates. The young spores germinate much quicker than the mature ones. The mature spore bulges slightly at the place from which the germ tube issues at germination. The germ tube generally arises from the side, but sometimes at one or at both ends, or from both cells on the same side.

Spore measurements.—Spore measurements were made from cultures on potato cylinders. The length and width of twenty spores in each culture for twenty-seven cultures was taken. The average dimensions are tabulated below:

Culture No.	Dimensions L.	W.	Culture No.	Dimensions L.	W.
1	24.58	14.58	15	22.56	11.86
2	19.86	11.92	16	20.12	11.31
3	25.04	12.84	17	24.44	13.44
4	25.32	14.18	18	25.46	14.56
5	25.30	13.96	19	25.58	15.50
6	26.02	14.04	20	25.68	14.82
7	25.44	14.00	21	25.64	15.92
8	25.22	13.96	22	22.64	12.84
9	24.30	13.92	23	24.86	14.46
10	26.64	14.50	24	26.43	14.18
11	24.62	13.48	25	25.20	13.58
12	25.30	14.06	26	26.50	14.64
13	25.18	13.80	27	26.36	14.46
14	24.68	13.04			

It was found that the spores measured from each culture varied in length from 19.86 microns in culture 2 to 26.64 microns in culture 10; and in width from 11.31 microns in culture 16 to 15.92 microns in culture 21. The spores measured from cultures 1, 3, 4, 5. 6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 18, 19, 20, 21, 23, 24, 25, 26 and 27 did not vary much. The majority of these cultures had about the same sized spores. The conidia varied in length and width. The variation of the spores from cultures 2, 15, 16 and 22 cannot be explained at present.

The writer believes that there were several species of *Diplodia* in his cultures. Harter (8) made isolations of four species of *Diplodia* from sweet potato, dasheen, cotton, *Toxylon pomiferum* Raf., and mango, and they showed the same characteristics in cultures. Macroscopically, the type of decay produced by each was identical to the "Java blackrot" of sweet potatoes. There is a slight variation in size and shape of spores of the organism from the dasheen and from the sweet potato. The spores from mango and from *T. pomiferum* Raf., agree in shape, but the spores of the fungus from the latter are much smaller in size. Pole-Evans (16) found that spores of five species of *Diplodia* from citrus showed great variation.

TAXONOMY

No attempt was made to study from a taxonomic standpoint the various organisms which were isolated. The study of their behavior in pure cultures, the similarity in appearance and in shape of the spores, together with the type of rots produced by cross-inoculations showed that some of them were identical.

The causal organisms found on cacao, sweet potato and *Hevea* have been named differently by various authors; and the four genera *Diplodia*, *Lasiodiplodia*, *Chaetodiplodia* and *Botryodiplodia* are used interchangeably.

The conclusion arrived at by Taubenhaus was briefly stated by Meier (13) in a paragraph which in part says:

> The members of the Sphaeropsideae which produce brown uniseptate spores are extremely variable. The distinctions between the genera *Diplodia*, *Botryodiplodia*, *Chaetodiplodia*, *Lasiodiplodia*, and *Diplodiella* have been based on slight structural variations in the pycnidia. The points of separation are the relation of the pycnidia to one another, whether scattered or cespitose; their relation to the host, whether subcutaneous, erumpent, or superficial; the presence or absence of bristles and of paraphyses. These are all characteristics which one might expect to vary somewhat with the characteristics or the condition of the host.

According to Taubenhaus (25), it seems advisable to prefer the generic name *Diplodia* to the others because the different genera established by different investigators for this group of fungi are based on slight structural variations from the genus *Diplodia*, which was the first one founded. In this manner all other generic names for the same organism may be eliminated. There are two other genera, *Rhynchodiplodia* and *Pellionellia*, which, according to Taubenhaus, may be placed under the genus *Diplodia*, or may be entirely eliminated if further study is made.

According to Stevens (21), there are over 450, mostly saprophytic, species of *Diplodia*. Studies of the measurements of spores of twelve species of this genus conducted by different investigators showed that the spores vary greatly, as they showed different characteristics on different hosts. In pure culture on corn meal, the spores of *D. Zeae* (Schw.) Lév. differed in measurement from the spores of the same organism grown on potato agar.

PHYSIOLOGY

A study of the growth of the 27 pure cultures isolated was made on sterilized potato agar and on cooked potato cylinders, for a period of 27 days. Observations were not made daily. The cultures on both kinds of media were placed under ordinary laboratory conditions. The cultures isolated from different sources grew well on potato cylinders and on potato agar, but grew faster on the former than they did on the latter.

Growth on potato cylinders.—On June 24, 1919, bits of mycelium of equal sizes were transferred into fresh potato cylinders by means of a sterilized platinum needle from each of the 27 cultures. It was found necessary to transfer nearly the same amount of mycelium for purposes of comparison.

It was found that in one day the mycelium grew radially and appeared as a cottony white growth covering an area of about one centimeter on the slanted surface of the medium. The whole surface was covered in two days by the same kind of growth, which, gradually, in three to four days, turned greenish black at the point of attachment with the medium. In six days the potato cylinders were shrivelled and the mycelium became black. The loss of moisture was noticed from the small droplets that collected around the inner wall of the test tube. The portion of the medium invaded turned black, and pycnidia began to form as small mounds. In thirteen days the medium was completely blackened and the aerial mycelium was grayish black. There were slight variations in the character and rate of growth, but in the final examination on the twenty-seventh day all were entirely black and the medium was dry and shrivelled. Pycnidia were present in all cultures.

Growth on potato agar.—On December 22, 1919, a cultural study was made of the 27 organisms of potato agar by the same method employed in the previous observation.

The organisms germinated the following day, and produced a circular growth on the agar. The white growth on the medium indicated that the mycelium was hyaline. On the second day the exposed surface of the agar was covered with whitish mycelium. The portion of the medium penetrated gradually turned greenish, then black. The color was distinct when the cultures were examined by transmitted light. In some cases where

growth was very vigorous, the tube was clogged with a dense whitish growth of aerial mycelium. The mycelium and medium became darker and darker in color, and pycnidia began to form. In twenty days, one-third to one-half of the medium was penetrated by the mycelium. The loss of moisture was also evident. There were slight variations in the rate and character of growth, but when old, one culture could not be distinguished from another. Pycnidia developed in cultures 1, 4, 6, 8, 13, 14, 19, 20, 21, 22, 25, and 27, when examined on the twenty-seventh day.

INSECT EXPERIMENTS

There are several kinds of weevils which attack the sweet potato, yams, and other stored root-crops. Not only do these insects do a great deal of damage themselves but they also cause great destruction, as they are carriers of fungus diseases to which the crops under consideration are susceptible. A brief study of the insects suspected as carriers of spores was conducted. Table III gives a list of insects and the crops on which they were found.

TABLE III.—*Insects found on stored roots, tubers, and fruits.*

Scientific name.	Stored crops attacked.
Cylas turcipennis Boheman	Sweet potatoes.
Calandra oryzae Linn.	Sweet potatoes, gabi, yautia, rice, corn.
Araeocerus fasciculatus De Geer	Sweet potatoes, cassava, gabi, yautia, tugue, dasheen, ubi, banana, cacao pods.
Tribolium ferrugineum Fabr.	Sweet potatoes, corn, gabi.
Alphitobius piceus Oliv.	Sweet potatoes, papaya.

INSECTS USED AND HOST CROPS

Brief description of the insects.—Of the weevils found exclusively on sweet potato, *Cylas turcipennis* Boheman, which is prevalent in the sweet potato districts of the United States, Sarawak, Java, India, Australia (15) and is very common in the Philippines, deserves special mention. This insect bores tunnels through the stored roots, and deposits its eggs in small cavities eaten out by the adult female. The larva burrows in the root in all directions, and the pupa rests at the end of the burrow. The adult insect, on emerging, comes out through the same tunnel and feeds on the potato. The infection gives the roots a sweetish odor, and the attacked portion is greenish black in color and bitter in taste.

This insect is described by Boheman (15) as follows:

"Length 3 lines (6 mm.); antennae as long as thorax and head; club of male antenna longer than preceding joints; beak not longer than head; elytra twice as wide as thorax at base, and twice longer than wide. The color description is as follows: Head obscurely viridicoeruleous; beak almost black; antennae rufo-ferruginous; thorax shining rufous; elytra coerulescent-virescent; thorax beneath rufous, remainder of body beneath coeruleo-virescent; legs rufous; tarsi beneath fulvous, spongy; female with femora in middle annulate virescent."

From a microscopic examination with a low power microscope, the insect was found to have hairy antennae, body, and legs.

The other weevils are of minor importance and attack only the diseased, dried, or partly dried sweet potatoes, yams, gabi, yautia, and cassava.

Araeocerus fasciculatus De Geer., a weevil found abundantly in the Philippines, Liberia and the United States and called by Herrick (10) a bean weevil, is the second most destructive insect. It infests coffee berries, cacao, beans, maize, corn stalks in the fields, cotton bolls, and seeds of wild indigo. In the

Philippines it is found on cacao pods, tuge, sweet potato, yautia, gabi, cassava, dasheen, banana, and ubi. All parts of the body are covered with hair-like structures.

Calandra oryzae Linn., commonly called a rice weevil, originated in India, and is destructive to stored grains, such as corn, rice, wheat, barley, oats, rye, and kaffir (29). It is also found on sweet potato, yautia, and gabi in the Philippines. The color varies from a shiny brown to black with red spots on the wing covers. All parts of its body, with the exception of the elytra, have hair.

Tribolium ferrungineum Fabr., known as a flour weevil, causes great damage to Indian corn, when shelled, and to other grains. It is widely distributed over Europe, Asia, Roumania, Hawaii, Guadaloupe, Madeira, Argentine, Canary Islands, Mexico, Guatemala, Costa Rica, Caracao, Brazil, Paraguay, Jamaica, West Indies, tropical and sub-tropical America, Asia and Africa (29). The writer observed it on corn, sweet potato, and gabi. This small weevil is reddish brown in color, and its legs and body are hairy.

Alphitobius piceus Oliv., was found on sweet potato and papaya. It has a black, shiny, grooved elytra, and the body is brown on the ventral side.

INSECTS AS CARRIERS

To prove whether or not the insects carry spores, a few of four species of insects were collected separately from diseased sweet potatoes with flamed forceps and placed in sterilized petri dishes. The insects were then introduced into the agar plates, in which they were shaken to shed any spores which might adhere on their bodies. After the insects were removed, the plates were examined for spores. Table IV gives the results.

TABLE IV.—*Microscopic examination of agar plates on which insects were allowed to walk.*

Insects used.	No. of insects.	No. of spores found.
Cylas turcipennis Boheman	7	31
Calandra oryzaee Linn	8	34
Tribolium ferrugineum Fabr	1	2
Araeocerus fasciculatus De Geer	3	6

The number of spores and of the insects used in each plate are shown in Table IV. There were probably more spores in the petri dishes; but due to the size of the agar plate it was rather difficult to examine every part of it thoroughly. It was not surprising to find that the spores were carried by these insects, for they all possess hair-like structures on some parts of their bodies, and the spores of the organisms are very minute and easily disseminated by almost any perambulating agent.

The spores carried by the insects germinated after twenty-four hours, producing the same characteristic growth as was produced by those isolated from diseased fruits and roots.

INFECTION OF SWEET POTATOES BY INSECTS OBTAINED FROM DISEASED SPECIMENS

On February 27, 1919, eight sweet potato roots were washed carefully in running water and then in mercuric chloride (1 to 1000) for ten minutes. They were then washed in two changes of sterile water and allowed to dry. Two roots were

placed in each of the sterilized glass jars. Before handling the sweet potatoes the hands were disinfected with alcohol. One root was wounded twice with a flamed and cooled scalpel, and the other was not. With the help of sterilized forceps the three kinds of insects were picked up carefully without touching the diseased sweet potatoes, collected in three separate sterilized petri dishes, and then transferred to their respective glass jars, which were covered with double cheese cloth with a thin layer of sterilized cotton in between. This safely guarded against the entrance of fungus spores and dirt, but permitted the entrance of air. The whole operation was carried on in a place free from draft, under laboratory conditions, and all the necessary precautions to avoid contamination were taken. The number of insects placed in each glass jar was not counted.

In the first jar in which *Cylas turcipennis* Boheman was introduced, one root was found infected on March 17, 1919. This root was badly punctured by the insects and showed the characteristic rot. The fungus was isolated. Very few of the insects remained alive till April 9, 1919.

In the next jar in which *Calandra oryzae* Linn., was placed, both roots were infected; one on March 17 and the other on March 19. Many of the insects perished because the roots were not in proper condition for the insects to feed on. This particular insect, unlike the first one, lives mostly on old, partly decayed and bruised roots. The organism was isolated from each root.

The insect *Araeocerus fasciculatus* De Geer. also caused an infection on the wounded root, but it was almost a month before the infection was noticed. This is the second most destructive insect and lives only on partially dry roots. The check kept for this set of experiments remained healthy.

A similar experiment was performed which differed from the preceding one only in that moist sterilized sand was placed at the bottom of the glass jars. It was found that the presence of additional moisture made the roots healthy. All of them grew, and this made them somewhat resistant to the disease. Although all the roots were attacked by the different insects introduced, only one out of the six was infected. The insect present in this particular jar was the *Araeocerus fasciculatus* De Geer, which moves very quickly. In this experiment the insects lived longer than in the previous one. The causal organism was recovered in pure culture when reisolated, and the check remained healthy.

DISCUSSION OF RESULTS

Of the organisms isolated in pure culture, only a few were determined. For convenience, the cultures were numbered consecutively from 1 to 27. Some of those used in this investigation were already identified as species of genera *Diplodia*, *Lasiodiplodia* and *Botryodiplodia*. To test whether these organisms would produce disease, a series of inoculations was made. In the first set of artificial infection tests, cultures 1 to 10 inclusive were used, and in the second series, cultures 1, 4, 9, 11, 15, 19, 20 and 24.

The behavior of the other organisms, which were not used in inoculation experiments, was studied, and observations were made of their growth. The result of the study is described under physiology. In that experiment it was found that all of the organisms isolated behaved alike on both potato cylinders and on potato agar. Morphological study also showed that these organisms had only one type of spore and mycelium. The spores, however, varied in size in

the different cultures, probably due to an effect of the medium used. The influence of different media on the size of spores, however, was not determined in this work. Further discussion on this subject is given under the heading morphology.

The results of the cross-inoculations seem to indicate that the species of *Diplodia*, *Lasiodiplodia* and *Botryodiplodia* are capable of causing disease when transmitted from host to host. It appears that all of the fungi used for cross-inoculations should fall under the same genus. The results of the two trials are clearly summarized in tables V and VI.

TABLE V.—*Summary of cross-inoculations with cultures 1 to 10, inclusive.*

Host inoculated.	Culture 1.	Culture 2.	Culture 3.	Culture 4.	Culture 5.	Culture 6.	Culture 7.	Culture 8.	Culture 9.	Culture 10.
Papaya fruit	5/8*a*	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8
Sugar cane cuttings	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8
Banana fruit, var.										
Hawaiian Dwarf	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8
Banana fruit, var. Saba	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8
Sweet potatoes	—*b*	—	5/8	—	—	5/8	5/8	—	5/8	—
Cacao pods	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8

Table V shows that the organisms isolated from sweet potato, mango, banana, cacao, coconut, cotton, jackfruit, papaya, mulberry, and sugar cane could all infect sweet potato, banana, cacao, papaya and sugar cane. The fruits were infected early, while sugar cane and sweet potato were infected much later. Cultures 1, 2, 4, 5, 6, 8, and 10 did not infect the sweet potatoes because of some unfavorable conditions which are explained in the latter part of this discussion. The nature of rots produced on all hosts were identical in every respect. The blackening of the host, the rapid loss of moisture, the production of small warty outgrowths, and the drying and shrivelling of the host were the main characteristics of the rot. On sugar cane, however, the pycnidia were produced on the rind as tiny pustules, or at the cut ends in groups.

TABLE VI.—*Summary of cross-inoculations with cultures 1, 4, 9, 11, 15, 19, 20 and 24.*

Host inoculated.	Culture 1.	Culture 4.	Culture 9.	Culture 11.	Culture 15.	Culture 19.	Culture 20.	Culture 24.
Sweet potatoes	5/8*a*	5/8	5/8	5/8	5/8	5/8	5/8	5/8
Cacao pods	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8
Mulberry cuttings	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8
Citrus trees (mandarin)	5/8	5/8	—*b*	5/8	5/8	—	5/8	5/8
Patani pods (green)	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8
Cassava cuttings	5/8	5/8	5/8	5/8	5/8	5/8	5/8	5/8
Papaya petioles	5/8	5/8	5/8	5/8	—	5/8	5/8	5/8
Citron fruits	5/8	5/8	5/8	5/8	—	5/8	5/8	5/8

From Table VI it will be seen that sweet potato, cacao, mulberry, patani, cassava, and citrus are all susceptible to the organisms used. Cultures 9 and 19, isolated from mulberry and cassava root, respectively, did not produce disease on branches of living citrus. Culture 15 did not infect papaya petiole and citron

fruit. Identical rots were produced on sweet potato and cacao as in the previous experiment when cultures 1 to 10 were used. The pods of patani and fruits of citron showed the same kind of rot.

Cultures 13, 14, 16, 25 and 27 were used for the inoculation of cacao pod, and caused them all to decay in the same way as those inoculated with other cultures. On cassava, cultures 1 to 14 were used, and the rots were the same throughout.

The following five varieties of citrus seedlings were inoculated: *C. maxima* (Burm.) Merr. was inoculated with cultures 1, 4, 9, 11, 15, 19 and 20. In this experiment only culture 11 developed. On the other varieties only culture 11 was introduced. Out of the four seedlings of *C. maxima* (Burm) Merr., two were killed, two were diseased in the wound, and one was not infected; of the five seedlings of Zabon, two were killed, two were infected in the wound, and one remained healthy; of the three seedlings of *C. nobilis* Lour. all the infection was confined to the wound. Only one of *C. medica* Linn. was inoculated, and it was killed. All the checks remained healthy. *C. maxima* (Burm.) Merr. showed a certain degree of resistance to the other cultures, but it was found equally susceptible to the organism isolated by Professor Reinking from the bark rot of *C. nobilis* Lour.

All organisms brought about decay at ordinary temperature, but a temperature slightly higher than that in the laboratory seemed to cause rot in a much shorter time. In the inoculation of fruits of *C. medica* Linn., other fungi grew when the fruits were completely decayed. They were taken out of the chambers and placed in a corner where the sun could reach them for about three hours in the afternoon. This changed the temperature condition of the environment slightly, and made it more favorable for the development of *Diplodia* than of the contaminating organisms. Therefore, when the inoculated fruits were nearly dry, the contaminations were destroyed.

The sweet potatoes inoculated in the second series of experiments were subjected to laboratory conditions, and decay of the roots was brought about more rapidly. Harter (8) inoculated sweet potatoes with *Diplodia tubericola* (E. and E.) Taub., and obtained good and quicker results by keeping them at a temperature from 34° to 35° C., than at 12.2° to 13.5° C.

Moisture was shown to be favorable for proper development of the organisms. Nearly all inoculations were carried on in damp chambers. In this condition the destruction of the hosts by the fungus was very quick. On sweet potatoes the presence of moisture did not hasten infection, for infection appeared slowly on those which were inoculated and confined in moist chambers. The first experiment on sweet potatoes showed that only three out of ten were infected. In the experiment when cultures 1, 2, 3, and 4 were used for the inoculation of the sweet potatoes, none took the disease; in the experiment in which cultures 1, 4, 9, 11, 15, 19, 20 and 24 were used, two out of eight roots became infected. The roots absorbed a considerable amount of moisture, and consequently sprouted. This made them somewhat resistant to the infection by the fungus. Newly harvested roots are not very susceptible, while the fruits are subject to the disease even if they are fresh. On the other hand, when no extra moisture was supplied, the eight sweet potatoes inoculated with cultures 1, 4, 9, 11, 15, 19, 20, and 24 all decayed. Harter (8), and Harter, Weimer and Adams (9) have shown that *D. tubericola* (E. and E.) Taub. grows well in a dry atmosphere or in ordinary laboratory conditions.

The insects used for the experiment were found on many stored crops which are susceptible to the disease caused by *Diplodia*. The last two of the insects (Table III) were found too late to be included in the insect experiments. The results obtained are not conclusive, and further experiments must be conducted before a definite statement, as to whether they carry disease, can be made. The three insects, *Cylas turcipennis* Boheman, *Calandra oryzae* Linn., and *Araeocerus fasciculatus* De Geer., were found by microscopic examination to carry spores of *Diplodia* on their bodies. A number of these insects were obtained from diseased sweet potatoes and introduced into sound ones, causing *Diplodia* dry rot to develop on some of the roots, which indicated that the insects probably transmitted the disease.

SUMMARY AND CONCLUSIONS

(1) Rots caused by *Diplodia* are prevalent on agricultural products in storage and in the field. *Diplodia* produces the disease on fruits, roots, and woody hosts. Much damage was observed on important products, such as sweet potatoes, cassava, gabi, yautia, yams, cacao, patani, and maize.

(2) Stored roots and fruits, as well as woody hosts in the field, were readily infected if near diseased hosts. The controls in inoculations were not infected with *Diplodia*.

(3) *Diplodia* and its allies are capable of attacking a variety of plants. About fifty diseases caused by *Diplodia* and its allies were found in the Philippines and around the College of Agriculture.

(4) Identical rots were caused by species of the three allied "genera", *Diplodia*, *Lasiodiplodia*, and *Botryodiplodia*, used for the inoculation of papaya, sugar cane, banana, sweet potato, cacao, mulberry, patani, cassava, and citrus.

(5) The characteristic rot was black and showed the presence of spore-bearing bodies. The final result of the disease was the drying out, hardening, shrivelling, and decrease in weight of the host through excessive loss of the moisture content.

(6) It was found that all the cultures used were capable of producing disease through wounds.

(7) Ripe or unripe fruits were susceptible to *Diplodia* and its allies.

(8) Younger branches of woody hosts were found to be more susceptible to the fungi than old stems, and in the latter the infection was frequently confined to the wound.

(9) On roots of sweet potato and cassava the organisms used demanded different conditions for their proper development. Sweet potatoes were more readily attacked under laboratory conditions than in a damp chamber. Moist conditions made sweet potatoes somewhat resistant. Probably this was due to germination which took place under these conditions. Newly harvested sweet potatoes were not susceptible. Cassava, on the other hand, was easily infected in the presence of excess moisture, and was readily infected even if newly harvested.

(10) Dampness appeared to favor the growth of the organisms on the whole, for most inoculations confined in damp chambers were successful. Field inoculations were also supplied with extra moisture.

(11) The sweet potatoes inoculated in the second set of experiments and the citron fruits inoculated, were placed in such a way that they were exposed to

sunlight from 3 p. m. to sunset. This made the temperature in the bell jar slightly higher than that in the laboratory. This condition apparently was favorable to the growth of *Diplodia* and its allies.

(12) Morphological study showed that there was one general type of spores and mycelium, but that the size of spores varied in the different cultures of the same medium.

(13) In cultures on the same medium the organism isolated from one host could not be distinguished from that isolated from another.

(14) There is reason to support Taubenhaus' (25) statement that the genus *Diplodia* alone should be retained. According to Taubenhaus, there are only very slight differences between *Diplodia* and the genera allied to it. He further states that the recently created genera may be abolished if further study is carried out. Some of the organisms isolated by the writer, which were determined as *Lasiodiplodia* or *Botryodiplodia* behaved in the same manner as *Diplodia* and could not be distinguished from the latter.

(15) The experiments conducted with the insects, *Cylas turcipennis* Boheman, *Calandra oryzae* Linn., and *Araeocerus fasciculatus* De Geer., were not numerous enough to permit the drawing of a definite conclusion that they transmit *Diplodia* spores. However, when some of these insects were obtained from diseased sweet potatoes and inclosed in glass jars with sound roots, infection was produced, which showed that possibly they may transmit the disease.

RECOMMENDATIONS

The recommendations herein formulated are based on observations and are the results of experiments.

(1) With the possible exception of sweet potato, all roots, fruits, and tubers should not be kept in damp places, as this condition promotes decay. It would be well to keep them in an ordinary well-ventilated store room.

(2) Fruits, such as papaya, banana, mango and cacao, should be marketed as soon as harvested unless they can be kept under proper storage conditions.

(3) Root crops and tubers should be kept in a cool, well-ventilated room.

(4) To avoid any injury, care should be taken in digging roots and tubers, in picking fruits, and in handling and hauling them. Observations showed that wounded roots do not decay when covered with lime. Lime should not be used in connection with roots preserved for seed.

(5) Useless handling in washing the roots and tubers should be avoided in order to minimize the danger of bruises.

(6) Disinfecting the storing place with a solution of formalin or of copper sulphate before storing the products would probably be beneficial. If disease appears, the sound products should be separated from the diseased ones, and the diseased ones should be disinfected to prevent further infection. This is recommended for roots stored for use as "seeds."

(7) Sanitation consisting of the collection and destruction of hosts diseased by *Diplodia* and its allies should be strictly followed.

(8) Since weevils and other insects in all probability carry the disease, they should not be allowed to walk or feed on the root crops and fruits stored.

The writer acknowledges his indebtedness to Prof. O. A. Reinking of the Department of Plant Pathology for his advice and encouragement; to Professor C. S. Banks, formerly of the Department of Entomology, for determining the insects; and to Mr. C. Mabesa of the Forest School for identifying some of the wood specimens.

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The College is very fortunate in securing the services of Professor J. E. Higgins, who arrived at the College in January, 1920, to take charge of the Department of Agronomy and Horticulture. Some personal notes concerning Professor Higgins are given below:

Born in Wolfville, Nova Scotia; son of Prof. D. F. Higgins, professor of mathematics in Acadia University. Graduated from Acadia University in 1895, with B. A. degree. Diploma, Nova Scotia School of Horticulture, 1896. M.S.A., Cornell Univ., 1898. Teacher of agriculture in Honolulu Normal School, 1898-1900. Supervisor of agriculture in Honolulu schools, 1900-1903. Horticulturist in Hawaii Experiment Station, 1903-1913. Professor of horticulture, Univ. of Porto Rico, 1913-1914. Horticulturist in Hawaii Experiment Station, 1914-1919. In charge of the Department of Agronomy and Horticulture, College of Agriculture, Univ. of the Philippines, 1920—. Publications: The mango in Hawaii; The pineapple in Hawaii; The banana in Hawaii; Citrus fruits in Hawaii; Marketing Hawaiian fruits; Shield budding of mangoes; The avocado in Hawaii; The papaya in Hawaii; The litchi in Hawaii; Marketing Hawaiian pineapples; The grape in Hawaii.

The following is a quotation from an article in the *Honolulu Star-Bulletin* Dec., 13, 1919:

Mr. Higgins' works have invariably been clear and concise enough for a novice to read and understand and, at the same time, have carried enough new and technical information to warrant their study by a scientist. The writer has seen Mr. Higgins' bulletins kept and quoted by practical men who usually pay no attention to any technical agricultural literature . . . . . During the war Mr. Higgins did much patriotic agricultural extension work. Considerable of the increased production in some parts of the [Hawaiian] islands can be attributed to him . . . . Hawaii is, indeed, sorry to lose this man who has been such a big factor in her agricultural development.

Prof. Harold C. Cuzner was appointed acting-dean, beginning February 3, 1920. He is the oldest member in years of service on the faculty staff.

President Villamor of the University of the Philippines, accompanied by Secretary Estella and officials from the Bureau of Health, visited the College on February 22 to confer with Dr. Francisco regarding anti-typhoid vaccination. During their stay they inspected the laboratories of the various departments. All of the students and faculty members have now received the preventive treatment.

Due to the untiring efforts of Regent Gonzalez and President Villamor, a first class post office, called Los Baños College, was officially opened on February 19, 1920. It is located in the main building, adjacent to the Plant Anatomy I laboratory. Mail should hereafter be directed to the COLLEGE OF AGRICULTURE, LOS BAÑOS COLLEGE, LAGUNA, PHILIPPINE ISLANDS.

Mr. Faustino Otanes, '18, formerly assistant in plant physiology at this College, and now a pensionado of the Bureau of Agriculture taking post graduate work in the University of Illinois, is living up to his promises. Prof. J. W. Folsom, of the University of Illinois, in a letter sent to Prof. C. F. Baker, speaks very highly of Mr. Otanes, as follows:

Mr. Otanes is certainly living up to your recommendation of him. He is one of the best students we have ever had; an enthusiastic and industrious worker; accurate and thorough; and bound to make his mark as an entomologist. He evidently had good training before he came here. It is a great pleasure to assist such a capable student, and we are giving him all the entomology he can digest, and of the kind that will be of most service to him and to the Philippines.

On March 5 Mr. Gonzalo Merino and Mr. José Camus, both graduates of the College and now with the Bureau of Agriculture, accompanied by a photographer, came to the College to take photographs of the buildings and laboratories. According to Honorable Jaime C. De Veyra, the pictures will be used in propaganda work in the United States.

Mr. Juan P. Torres, '19, assistant in Rural Economics, College of Agriculture, resigned on February 1, 1920. He is now in charge of seed distribution, Bureau of Agriculture.

Mr. Mariano Raymundo, manager of Dr. Copeland's rice plantation and formerly a student of the College of Agriculture and a graduate of the University of Wisconsin, visited the College on February 9 to get graduates and undergraduates from the college to work on Dr. Copeland's rice plantation at Chico, California. Mr. Hilarion H. Silayan, '17, and Mr. Andres Goseco, '20, agreed to go with Mr. Raymundo.

The annual meeting of the stockholders of the College Co-operative Co., Inc., was held on February 28. The following is a summary of the business transacted:

(1) Reading of the minutes by the Secretary, Prof. O. A. Reinking.

(2) Essence of Auditing Committee's report given in brief by Prof. O. A. Reinking.

(3) Oral explanation of the Report of the Board of Directors by the President (Prof. B. M. Gonzalez).

(4) Distribution of Profits as Approved by the Board of Directors (February 1, 1920).

Profits on 1919 Operation

Spent to complete building	388.01	
Undivided Profits	1976.18	2364.19

	Credit	*Debit*
For completion of building as approved by Board of Directors	388.01	
To be distributed to stockholders on basis of 20% of purchases	1460.12	
2% of net profits for storekeepers	47.28	
1% for Mr. José Marfori		
½% for Alejo Taléon		
½% for Ambrosio Lontoc		
Building fund	468.78	
TOTALS - - - - - - ₱	2364.19	₱2364.19

(5) Outline of 1920 plan by the manager.

(6) Election:

President.....PROF. B. M. GONZALEZ.
Vice-President.....PROF. O. A. REINKING.
Sec.-Treasurer.....PROF. O. A. REINKING.
Directors: DR. M. L. ROXAS, DR. R. B. ESPINO and MR. T. VIBAR.

The following seniors were graduated on April 5, 1920:

MASTER OF SCIENCE IN AGRICULTURE

1. Vicente C. Aldaba, B. S. Agr.
2. Tomas Vista y Isles, B. Agr.
3. Mariano G. Medalla, B. S. Agr.
4. Gerardo Offemaria Ocfemia, B. Agr.

BACHELORS OF SCIENCE IN AGRICULTURE

1. Antonio Derecho y Perez
2. Isidoro Guzman y Dalafu
3. Mariano Jurado y Cortez
4. Policarpo Padlan y Aquino
5. Pedro Paulino y de Leon
7. Gaudencio M. Reyes.

BACHELORS OF AGRICULTURE

1. Africa, Angel A.
2. Capinpin, Jose M.
3. Clara, Feliciano M.
4. Carandang, Atanacio T.
5. Catalan, Nemesio
6. Cazeñas, Gregorio D.
7. Collado, Isidoro I.
8. Corrales, Jose P.
9. Eladya, Aniano
10. Festin, Simplicio F.
11. Goseco, Andrés P.
12. Jamias, Julio M.
13. Limbo, Anastacio M.
14. Lizaso, Juan G.
15. Lontoc, Ambrosio
16. Lontoc, Gregorio
17. Mañgonon, Alejandro
18. Morada, Emilio K.
19. Morada, Julian
20. Mariano, Severo J.
21. Palafox, Serapio
22. Pugeda, Melquiades
23. Ramos, Florentino
24. Rojales, Pedro
25. Estalilla, Hilarion
26. Labrador, Anselmo
27. Canonizado, Maximo P.
28. Villanueva, Crispin
29. Villanueva, Leon B.
30. Villaraza, Mariano F.
31. Tomaneng, Roman G.

Balintawak Circle, a society made up of "Rizaleños," gave a party at the Ideal Hotel, Los Baños, in honor of those who graduated from the College of Agriculture. Mr. and Mrs. Nemesio B. Mendiola were guests.

Mr. Fernando D. Luistro, '15, resigned as instructor of Agronomy to take up work in the Bureau of Education. He is in charge of the Balactasan Scientific Center, Basilan.

The annual meeting of the Philippine Society of Technical Agriculturists was held at Hotel de France on February 1. Incorporation of the association was the main topic of discussion. The following officers were elected:

President.....MARIANO M. CRUZ.
Vice-President.....ANTONIO LEJANO.
Secretary.....TORIBIO VIBAR
Treasurer.....JOSE CAMUS.

Mr. Vicente Dawis, '16, formerly assistant in charge of coffee, cacao, and coconut projects at the Calamba Sugar Estate, was appointed as farm superintendent at the College of Agriculture, and reported for duty February 2.

Animal Husbandry I students, accompanied by Prof. B. M. Gonzalez, made a trip to Alabang and Manila, February 2-3.

The Agronomy IV class, headed by Professor Elayda made their annual trip to Manila and Lamao Experiment Station at Bataan, February 2-6.

The Student Body of the College of Agriculture gave the following program at 7:30 o'clock January 29th in the Auditorium in honor of Dean C. F. Baker, who left for the Southern Islands:

1. *Piano solo*.....Felipe Jaojoco
2. *Remarks by the president of the student body.*
3. *Speech*.....Prof. B. M. Gonzalez
4. *Musical Selection*.....D. Aquino and F. Jaojoco
5. *Remarks*.....Prof. F. W. Ashton
6. *Remarks*.....Dean C. F. Baker
7. *Musical selection*.....D. Aquino and F. Jaojoco

About four hundred and fifty students of the freshman class, Manila High School, visited the College on February 22, Washington's Birthday. The main events of the day were dancing and sight-seeing.

Working fellowships.—Beginning in 1920 assistantships in the College of Agriculture and in the Experiment Station will be in the nature of working fellowships for a one year period with annual stipend of ₱960.00 for first appointments, and ₱1,200 per annum for succeeding appointments in subjects involving laboratory work or supervision. The primary object of these fellowships is to furnish assistant material for the different departments; and for purposes of administration, the fellows will be known as assistants in the department to which they are appointed.

These fellowships are open to holders of bachelor degrees from this College, or from elsewhere if the degree is equivalent to that granted by the College for the work that will be required of the candidate. Candidacy to these fellowships must be endorsed by the member of the Faculty in need of an assistant, through the head of the Department, to the Dean. There is no prescribed form of application. In recommending for fellowship two points must be borne in mind: (1) The need of the College for the service to be given by the appointed fellow; (2) Suitability of the candidate for this service.

Fellows shall be required to render at least five hours work daily in the department to which they will be assigned, outside of the time devoted to study. Such work will be in the nature of help in the class room, laboratory, field work, or elsewhere, depending on the requirements of the department. Holders of fellowships must take in the College or other units of the University at Los Baños, from five to ten credits of work, but not to exceed the time equivalent of two five-credit laboratory courses a semester. Under special permission from his immediate chief and the head of the department, the Dean may allow a fellow to enroll for more than 10 credits if only one or no laboratory course is carried. At no time will a fellow be allowed to devote more than 20 hours a week to studies.

That his studies will not be in conflict or interfere with the work for which he is employed, a fellow shall elect his course in consultation with his immediate superiors, and his program must bear his superiors' approval before being presented to the Registrar. Time devoted to such study is for self-improvement and for increased efficiency in the service and may, therefore, be considered as

official. Seven hours, daily, of service in department and class room or laboratory work shall be obligatory, except on Saturday, when the required hours will be five. Fellows will be granted vacation and accrued leave privileges. If it is desired to renew the fellowship, which is of one year's duration, steps should be taken one month before its expiration; otherwise, the fellowship ceases automatically. Working fellowships may be renewed as many times as may be found desirable.

INDIAN BULLS FOR SALE

The College has five Indian bulls for sale, ranging from 1 year to 2 years old. Prices ₱150.00 to ₱200.00.

Apply to the Dean, College of Agriculture, Los Baños College, Laguna.

IN MEMORIAM

JUAN JIMENEZ

SINGALONG, MANILA

First Year Preparatory Course

DIED AT HIS HOME

FEBRUARY 1, 1920

IN MEMORIAM

MARIANO FRIAS

SAN CARLOS, PANGASINAN

Second Year Preparatory Course

DIED AT PHILIPPINE GENERAL HOSPITAL

JANUARY 30, 1920